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**IN THE UNITED STATES PATENT & TRADEMARK OFFICE**

Appln. Ser. No.:	Filed:	Inventor(s):	Atty Dkt:
10/073,448	11 Feb. 2002	F. Norman	102FN-001A
Title: Fuel Additive Containing Lithium Alkylaromatic Sulfonate and Peroxides			
Examiner: Cephia D. Toomer		Art Unit: 1714	

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

**DECLARATION OF FRANK L. NORMAN**

Dear Sir:

In connection with the subject patent application, I hereby declare as follows:

1. My name is Frank L. Norman, the sole inventor of the patent application identified in the caption. I was awarded a B.A. in Chemistry from Lafayette College. After serving in the United States Army, I worked in various chemical companies (Union Carbide, Pennwalt, ARCO), among other employment, before starting my own companies.
2. On March 24, 2003 I contracted with the University of Southern Maine to run 10 sets of data on vehicles using a composition described in my patent application. The final report ("USM Report") was rendered on 12-31-03 and was sent to me; a copy of that report is attached. The report showed an overall increase of 8.9% in miles per gallon in a mixed fleet of 7 vehicles.

3. The BORGASM fuel additive mentioned in the USM Report is my fuel additive. My company, Future Fuel Technologies, is the owner of U.S. Trademark Reg. No. 2,673,141 for BORGASM for "chemical additives for fuel treatment."
4. The BORGASM fuel additive composition that I provided to USM for use in generating the USM Report, and the additive provided to Irving Tanning Co. for use in the experiments described in the declaration by Jamie Ryder, were both provided by me and contained 35 % of lithium dodecylbenzenesulfonic acid, 6 % of *t*-butyl peroxide, and 3 % of MEKP.
5. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

  
Frank L. Norman

8/2/04  
Date

School of Applied Science, Engineering,  
and Technology (ASET)  
Engineering Assistance  
Productivity Analysis  
Lean Manufacturing  
Industrial Training  
Quality Assurance  
Product Testing  
Plant Layout  
Prototyping

37 College Avenue  
Gorham, ME 04038  
(207) 780-5313  
TTY (207) 780-5646  
FAX (207) 780-5129  
wmoore@usm.maine.edu

**PRELIMINARY TEST RESULTS  
FOR  
FUTURE FUEL TECHNOLOGIES, INC.**

**PRODUCT  
BORGASM FUEL ADDITIVE –  
MILEAGE ENHANCEMENT PRODUCT**

**MANUFACTURING APPLICATIONS CENTER  
PRODUCT TESTING LAB  
DR. WILLIAM H. MOORE, DIRECTOR  
UNIVERSITY OF SOUTHERN MAINE  
GORHAM, MAINE**

**MAY 29, 2003**

## PRELIMINARY TEST RESULTS

### Overview

As of the date of this report, five randomly selected vehicles have been studied and their fuel mileage calculated both before (i.e., baseline) and after using the Borgasm additive at a ratio of 1 ounce additive per each 10 gallons of gasoline.

The table below identifies the vehicle with engine size, the baseline without additive, and the difference in results with the additive. In all cases, each vehicle had a minimum of five tankfuls/fillips of fuel consumed during each phase of the test.

VEHICLE IDENTIFICATION RESULTS TABLE			
Vehicle Identification	Baseline Mileage without Additive	Mileage with Additive	% Difference
8 cylinder, 14 passenger van, #19	15.72 mpg	16.9 mpg	7.5%
8 cylinder, 14 passenger van, #17	15.32 mpg	16.89 mpg	10.3%
8 cylinder, 14 passenger van, #22	14.59 mpg	16.54 mpg	13.4%
6 cylinder mini-van	21.38 mpg	23.74 mpg	11%
8 cylinder Jeep	13.75 mpg	14.42 mpg	5%

Additional vehicles are being tested at the present time, and results will be calculated as the data is collected.

Examiner: Dr. William H. Moore



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**DECLARATION OF JAMIE RYDER**

Dear Sir:

In connection with the subject patent application, I hereby declare as follows:

1. My name is Jamie Ryder. I am the Chief Engineer at Irving Tanning Co., Hartland, ME. I earned a State of Maine 2<sup>nd</sup> Class Engineer License, which is required for running high pressure equipment. I was awarded an A.S. degree from Husson College, Bangor, Maine, in 2003.
2. My responsibilities at Irving Tanning Co. include oversight of a high pressure boiler system, which is a closed loop system providing steam to various plant loads. These loads include heating process water to 170°F (250,000 gal/d; roughly 40% of the total load), process steam for drying and vacuum (roughly 30% of the total load), and facilities heating (roughly 15% of the load); the system is about 10% inefficient.
3. The usual method employed at Irving Tanning Co. for evaluating fuel costs for the boiler system is a calculation of the ratio of the pounds of steam produced to the gallons of fuel used. Steam is produced at

saturation at 70 psi, and the fuel is No. 6 fuel oil. This type of oil is a thick, viscous tar-like liquid made by blending heavy residual oils with a lighter oil (often No. 2) to obtain a specified viscosity and pour point; its specific gravity can vary from 0.95 to 1.03, and it must be heated to flow. Also, the content of various constituents (such as vanadium and sulfur) varies with each batch of oil delivered.

There is an 800 HP Cleaver-Brooks boiler at the facility that includes a "fuel treatment" system that accommodates the addition of additives to the fuel just prior to the burner gun.

The boiler system runs for 24 hours a day, seven days a week.

4. Under my direction and control, an additive supplied by Frank Norman was tested to determine whether the additive would provide any improvement in the steam:fuel (S:F) ratio. To make mixing easier and more homogeneous, the additive was mixed with No. 2 fuel oil (as a vehicle) prior to being mixed with the No. 6 fuel oil via the fuel treatment system.

Three sets of tests were conducted.

The first tests were conducted during four consecutive days in the fall of 2003. These results are shown in the following table, where the amount of fuel and additive are in gallons, and the steam produced is in pounds. As mentioned above, the boiler runs for 24-7, so the amount of fuel oil, additive, and steam are those generated in a 24 hour period. The "%  $\pm$ " is based on using an average of days 1 and 4 as a baseline.

Day	No. 6 / Additive / No. 2	# Steam	S:F	% $\pm$	Additive:No. 6
1	1900 / 0 / 0	264,860	139.4	n/a	n/a
2	2710 / <2.5 / <2.5	386,740	142.7	2.31	> 1:1084
3	2390 / >2.5 / >2.5	366,090	153.18	8.99	< 1:1084
4	1830 / 0 / 0	253,090	138.3	n/a	n/a

Later in the fall of 2003, with colder weather and thus a higher steam demand, additional trials were conducted on four consecutive days, with the results shown in the following table:

Day	No. 6 / Additive / No. 2	# Steam	S:F	% $\pm$	Additive:No. 6
1	3310 / 0 / 0	389,860	117.78	n/a	n/a
2	3120 / 3.5 / 3.5	423,180	135.63	12.07	1:891
3	3280 / 2.5 / 2.5	450,230	137.27	13.12	1:1312
4	3420 / 0 / 0	413,980	120.69	n/a	n/a

Because the baseline data can vary with the weather, and a 5% variance is possible on any given day (based on the weather and different inefficiencies in different loads), I undertook further testing in March of 2004, using as a comparison or control a day in February of 2004 having the closest fuel consumption. In the following table, the testing date is given an "m/dd" and the control date is "m/ddC."

Date	No. 6 / Additive / No. 2	# Steam	S:F	% $\pm$	Additive:No. 6
3/16	4050 / 1 / 1	492,260	121.55	-0.99	1:2025
2/24C	4070	500,000	122.85		
3/17	4010 / 4 / 4	545,350	136.00	+1.79	1:1002
2/11C	4020	536,910	133.56		
3/18	3930 / 6 / 6	522,240	132.89	-1.8	1:655
2/17C	3910	529,140	135.33		
3/19	2910 / 5 / 5	374,430	128.67	-1.61	1:582
2/13C	2970	388,410	130.78		

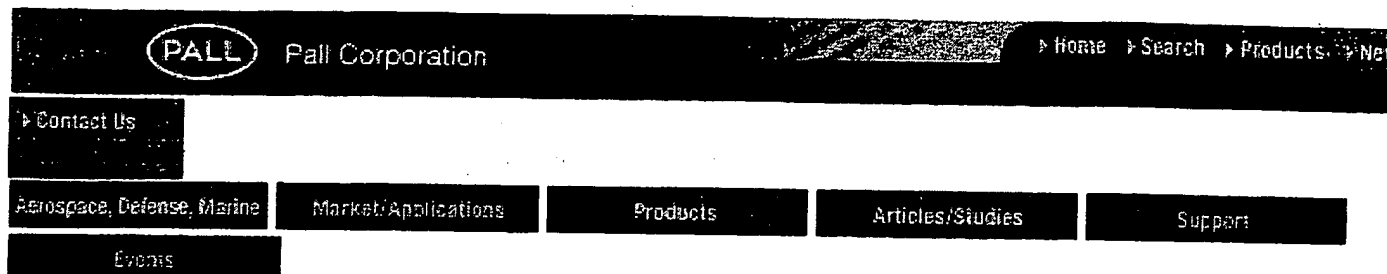
3/22	3420 / 3 / 3	524,240	153.29	+10.03	1:1140
2/18C	3510	484,100	137.92		
3/23	3880 / 2 / 2	490,650	126.46	-2.16	1:1940
2/19C	3900	504,060	129.25		

5. In the foregoing tests, our existing measuring devices were used. The pounds of steam was determined using a Kent Taylor brand orifice plate, and the amount of fuel was measured using a Trident brand meter (wobble plate type).
6. Based on the foregoing tests and conditions, it is my opinion that a fuel savings of about 10% is achieved using the additive in a ratio between about 1:900 and about 1:1300 with respect to the amount of No. 6 oil.
7. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Jamie Ryder  
 Jamie Ryder

7/28/04  
 Dated





## Improve Suspended Water Removal from Fuels: A better understanding of molecular forces enhances free water separator selection (Reprint from Hydrocarbon Processing)

### A better understanding of molecular forces enhances free water separator selection

R. L. Brown, Jr., and T. H. Wines, Pall Corp., East Hills, NY  
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#### Webmaster's Note

##### Webmaster's Note:

This document uses Greek letters which cannot be easily rendered in pre-HTML 4.0 browsers. To ensure compatibility we are using graphic versions of the characters, inlined with the document text. You may notice that these characters do not match the document typeface. This is unavoidable.

$\Delta$	$\mu$	$\rho$	$\sigma$
Delta	mu	rho	sigma

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#### Introduction

Molecular forces, such as interfacial tension (IFT), viscosity, relative density and temperature, control water removal from fuel/water mixtures. A better understanding of these physical properties will aid in investigating separation techniques. Equations and case histories review several free water removal methodologies such as salt driers, liquid/liquid coalescers, etc., and their effectiveness on emulsions.

surfactant-containing streams.

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### A big problem

Today, water contamination in refinery fuels can be a bigger problem than solids contamination. It corrode and plug engine parts and is a significant contributor to tank bottom corrosion and bacteria. In addition, water may contain corrosive materials like chlorides that will cause equipment damage. It doesn't take much water to cause a problem. Water concentrations as low as 100 ppm can cause off-specification due to haze, color or overall water concentration. Detergents and additives that make water removal more difficult because they lower the interfacial tension between water and

Field tests conducted at two refineries show how a stacked coalescer/separator configuration with medium outperforms salt driers in terms of total water removal from diesel fuel and do not disarrange (coalesce) when exposed to surfactants like conventional glass fiber coalescers.

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### Difficult to remove

Two forms of water can be present in fuels: dissolved or suspended as tiny droplets that range in size from 0.1  $\mu\text{m}$  to 10  $\mu\text{m}$  in diameter. This size is so small that it cannot be visually detected except when concentrated haze is formed. The free water is suspended as an emulsion. The more stable the emulsion, the more difficult it is to remove the water. Factors that affect water removal from a water/fuel mixture are interfacial tension, viscosity, relative density and temperature.

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### Interfacial tension

The ability to remove water improves as the IFT between the two phases increases. The IFT ( $\sigma$ ) between two liquids is a measure of the attraction force between each phase for its own species. At a two-liquid interface, a natural surface tension is created as each phase is repelled by the other phase. A ring-pull method is used to measure IFT. This method measures the force required to pull a platinum-iridium ring of a certain circumference from one discontinuous phase into the next. The typical units of IFT are dyne/cm. IFT is a critical factor when considering liquid/liquid coalescence because the largest possible stable droplet size that can be formed by the coalescence process will be dictated by IFT. A system with a high IFT (i.e.,  $\sigma > 20$  dyne/cm) can sustain a larger stable coalesced droplet size, which can be easily separated. Systems with a low IFT (i.e.,  $\sigma < 20$  dyne/cm) form smaller stable coalesced droplets and require high efficiency separators. Besides IFT, the coalesced droplet size will also depend on the system dynamics including relative droplet velocity, density and viscosity.

One method for correlating drop size to flow conditions has been developed by Hu and Kintner.<sup>1</sup> The drag coefficient ( $C_d$ ) of different organic drops in water is related by a physical property group (P) and Weber number (We) over a range of Reynolds numbers (Re). A unique curve is produced when  $C_d \cdot \text{We}$  is plotted against  $\text{Re}/P^{0.15}$  where

$$C_d = \text{Drag coefficient} = 4gd \Delta \rho / 3 \rho_o V^2$$

$$P = \text{Physical property group} = \rho_o^2 \sigma^3 / g \mu_o^4 \Delta \rho$$

$$\text{We} = \text{Weber number} = V^2 d \rho_o / \sigma$$

$$\text{Re} = \text{Reynolds number} = \rho_o V d / \mu_o$$

$V$  = Terminal velocity

$d$  = Droplet diameter

$g$  = Acceleration due to gravity

$\rho_o$  = Density of continuous phase

$\mu_o$  = Viscosity of continuous phase

$\Delta \rho$  = Density difference between droplet and continuous phase

$\sigma$  = Interfacial tension

Conventional coalescers can work effectively on mixtures with an IFT no lower than 20 dyne/cm, that reduce IFT, and make coalescing more difficult, include using surfactant-containing inhibitors additives with the fuel. In addition, solid contaminants also lower the IFT. Refined fuels that contain may have an IFT of 10 dyne/cm or lower.<sup>2</sup>

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### Viscosity

Liquid media viscosity has a significant impact on the coalescence process. The two droplets must pass through the liquid and collide. The next step is fusion of the two droplets, which requires the breaking of the liquid/liquid interface between the droplets. Both steps in the coalescence mechanism are impeded by viscosity. The droplets must overcome a higher drag force to reach one another. The breakdown of the liquid/liquid interfaces to create larger fused droplets is made more difficult by a higher viscosity. A longer residence time is required to accomplish the same coalescence level compared to a lower viscosity. This can be done by either lowering the flowrate or increasing the coalescer medium's area.

The  $\Delta P$  across the coalescer will also be affected by viscosity:

$$\Delta P = K\mu Q$$

where

Q = Flowrate

$\mu$  = Viscosity

K = Medium constant (coalescer).

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### Relative density

The relative density between the two phases to be separated (e.g., water from gasoline) can have an effect on coalescer performance. As the density of the coalesced liquid to be removed approaches the liquid's density, separation becomes more difficult.

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### Temperature

The fuel/water mixture's temperature can also affect separation efficiency. As temperature increases, the water droplets' size decreases, lowering the water droplets' size. In addition, fuels saturated with water at high temperatures contain a high concentration of dissolved water, which cannot be removed by liquid/liquid coalescing. As temperature decreases, the water falls out of solution into a suspended state and can then be removed by a liquid/liquid coalescer.

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### Surfactants -- double trouble

Not only do surfactants reduce coalescer efficiency by lowering the IFT, they also disarm the conventional filter coalescer, which is one of the biggest operational problems. When a liquid/liquid coalescer operates efficiently, water molecules bond with the silanol functional group (Si-O-Si) of the glass fiber. The water molecules that collect on the glass fiber coalesce with incoming water molecules to form larger droplets that eventually become heavy enough to drain from the coalescer. In an efficiently operating coalescer, the water molecule has fallen from the silanol functional group; the coalescing process repeats (Fig. 1).

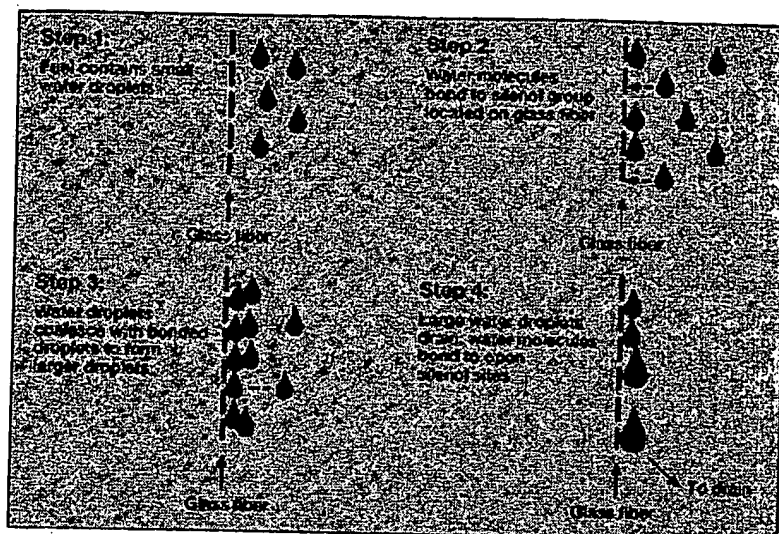
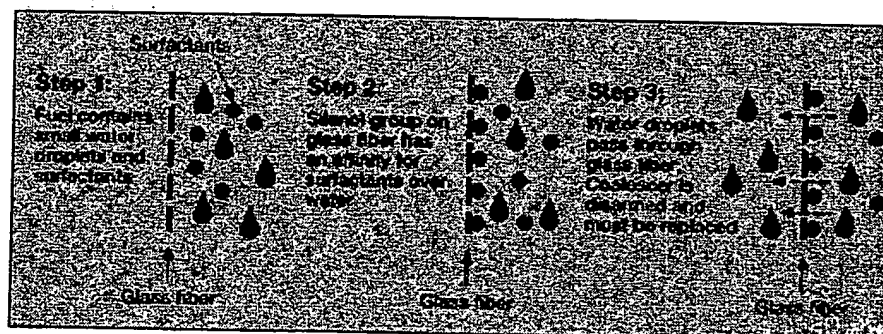


Figure 1. Simplified mechanism for effective coalescing.

Disarming occurs when surfactants bond with the silanol functional group. The silanol group has a higher affinity for surfactant molecules than for water. As the surfactant bonds to the glass fibers, the water molecules are repelled, reducing the probability of water breakthrough and shortening the coalescer's service life. Result: frequent and increased disposal cost of coalescer cartridges.



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## Other water removal technologies

Conventional technologies used to remove water from fuel include:

- Tank settling, which may be unreliable and take several days, an unacceptable amount of time to remove the water effectively
- Sand filters, which have high capital costs and may not always be efficient
- Salt driers, which experience temperature sensitive operational problems and can add cost to the fuel.

A fuel stream may go through one or more of these methods to meet a refinery's haze or moisture specifications.

Some problems experienced with salt driers include bridging, which results in poor overall usage (50%)<sup>4</sup> of the salt and channeling, which is large hole formation throughout the length of the drier, caused by high flowrates and poor distribution through the drier. Maintenance problems such as corrosion occur at lower temperatures.<sup>6</sup> In addition, any water that remains in the fuels after it flows through the drier will contain chlorides, which can result in corrosion problems downstream in tanks, piping and engines. Drier efficiency is best when operated within a relatively low temperature range and at a steady flow rate. Salt driers can remove dissolved water where coalescers may only remove free or suspended water.

However, liquid/liquid coalescers should have the advantage of removing free water from hydrocarbons on a continuous and reliable basis. They should not add any potentially corrosive materials to the fuel stream.

removal efficiencies and relatively low capital and operating costs. Liquid/liquid coalescer can op  
at fluctuating flowrates and temperatures.

Better stream preparation improves downstream coalescing. A newer design uses a filter stage t  
particulates and has a stacked coalescer/separator configuration with polymeric medium to impr  
distribution and overcome disarming (Fig. 3). This design results in improved reliability and lower  
(Table 1).

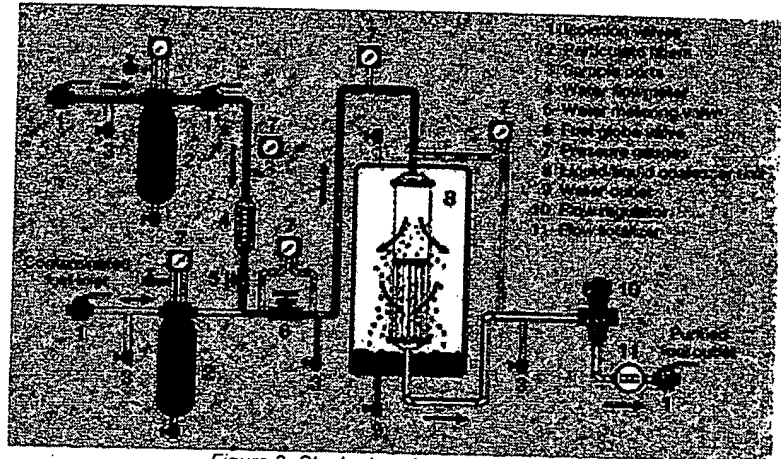


Figure 3. Stacked coalescer/separator.

Table 1. Estimated operating costs of stacked coalescer/separator system for different

Fuel	Viscosity, centistokes 100°F	Operating costs, ¢/gal
Gasoline	0.7	0.015
Jet A	1.6	0.023
Jet B	2.3	0.024
Diesel (2-D)	3.5	0.032
No. 2 Fuel oil	3.6	0.033
No. 4 Fuel oil	8.5	0.067

\*Assumes a 20,000-bpd flowrate.  
Includes both filter and coalescer/separator stack replacement costs.  
Does not include initial capital and installation costs.  
Filters sized at 0.5 gpm/ft<sup>2</sup> and changed out eight times/year.

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### Laboratory tests

Tests conducted at an independent laboratory on unleaded gasoline used a stacked coalescer/s  
test protocol closely followed API 1581 Jet Fuel Separator qualification and specifications. 7 The  
unleaded gas mixtures charged to the test unit was 3 dyne/cm to 7 dyne/cm. A finely divided wat  
gasoline was used to challenge the coalescer. Free water concentration in the inlet mixture was  
ppm to 3% (30,000 ppm) by volume. In all test cases, the effluent concentration of free water afte  
through the coalescer was less than 15 ppm by volume.

Testing also demonstrated the limitations. The coalescer stage size is limited by  $\Delta P$  and by the  
coalescing mechanism. Design flow through the coalescer is inversely proportional to the viscosi  
cSt. Results showed that a 20-in. long coalescer (3-3/4 in. diameter) can handle a flowrate of 30  
(viscosity = 0.7 cSt) for a clean  $\Delta P$  of 5 psid. The same sized coalescer can handle 6 gpm of a c  
(viscosity = 3.5 cSt) when sized for equivalent pressure drop and water removal efficiency.

The separator is velocity limited and not adversely affected by increasing viscosity. Water breakt  
within the separator once a maximum velocity or flowrate is reached. The design velocity for the  
available 20-in. separator is 30 gpm regardless of viscosity.

These stage limitations indicate that a larger coalescer stage with the same sized separator can handle twice the flowrates for more viscous fluids. A 40-in. coalescer/20-in. separator, for example, can handle twice the flowrate of a 20-in. coalescer/20-in. separator. Because lower viscosity fluids like gas are removed by the separator, a larger coalescer does not improve the flowrate per coalescer/separator stack.

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## Field results

Field tests were conducted at two refineries on diesel streams. The water source in diesel can be steam stripper at the back end of a diesel hydrotreater. When the diesel exits the steam stripper the water is dissolved. As the diesel cools water drops out of solution into suspension. Because it is important to remove suspended water, it is important to locate the coalescer in the coolest possible location.

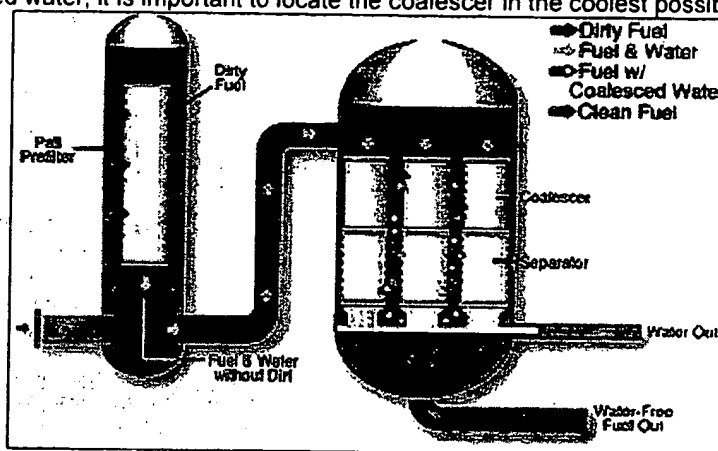


Figure 4. Liquid/liquid coalescer side-stream test stand.

Fig. 4 is a schematic diagram of the side-stream coalescer field test apparatus. It consists of a 3 prefilter, a coalescer/separator stack enclosed in a glass filter housing, and associated valves and pressure and temperature measurements. An inline flowmeter measured the stream's flowrate. The coalescer consisted of a 6-in. coalescer stacked on top of a 6-in. separator. Fuel samples were taken upstream and downstream of the coalescer for water content measurements.

## Refinery A

At a major U.S. refinery, conventional diesel is prefiltered by 10  $\mu$ m absolute filters, flowed to a coalescer (CaCl<sub>2</sub>) tower for water and haze removal. In terms of haze, the salt drier at Refinery A was minimal efficiency in haze removal when fluid temperatures exceeded 100°F. Haze temperature increased to approximately 10°F at temperatures around 75°F. After flowing through the salt drier filtered by 10  $\mu$ m absolute filters to remove salt particles and other solids. Salt tower operation is expensive, requiring extensive maintenance due to salt pluggage and disposal. In addition, approximately 10% of the diesel that is processed through the drier is off-specification due to temperature-related haze.

Table 2 summarizes the test results. The diesel entering the test stand typically contained over 1 ppm water with an average haze rating of 6. Downstream of the stack, the free water contents were below 1 ppm. The filtrate samples for 1 gpm, 1.5 gpm and 2 gpm were bright and clear with an average haze rating of 1. At a flowrate of 3.5 gpm, a coalescer limitation was reached due to high differential pressure. The average haze rating increased to between 2 and 3.

Table 2. Summary of test coalescer test results at Refinery A

Fluid: #2 Diesel  
Viscosity: 3.5 cSt at 100°F  
Fluid temp.: 97°F

Flow, gpm	Stack pressure drop, psid	Haze test*, coalescer inlet	Coalescer inlet free water, ppmv	Coalescer outlet free water, ppmv	Haze test*, coalescer outlet
1	2	6	120	11	1

1.5	2	6	120	10	1-2
2	4	6	120	9	1
3.5	11	6	120	6	2-3

\* based on Colonial Pipeline Co. "Line Chart" system.

The total water content of the samples collected at flowrates from 1 gpm to 2 gpm compared favorably with samples taken downstream of the salt drier (110 ppm collected at ~ 100°F). Operating costs analysis indicates a significant difference between the salt drier and the stacked coalescer (Table 3). High materials and disposal costs of the drier more than offset the incremental costs required for additional coalescer stacks. Use of the coalescer either in place of, or in conjunction with, a salt drier is being considered as a refinery expansion.

**Table 3. Comparison of operating costs between salt drier and stacked coalescer/separator system at Refinery A**

Item	Incremental annual costs of operating coalescer
Filter usage	(\$24,000)
Coalescer usage	(\$36,000)
Salt (includes maintenance, material and disposal)	\$240,000
Total	\$180,000*

\* Does not include benefits resulting from reducing amount of off-test product, which is currently 4% of the diesel run through this drier.

#### Refinery B

A medium-sized U.S. refinery removes water from diesel with a horizontal separator and an NaC. During the warm weather months (May to September), the diesel has occasional haze problems requiring additional drying. Refinery B's quality check is called the haze clear-up temperature, which involves drying the diesel until a stable haze appears and then slowly reheating it until the haze disappears. The temperature at which the sample starts to clear is recorded as the haze clear-up temperature. The lower the haze clear-up temperature, the drier the sample.

Test results are summarized in Table 4. The diesel entering the test stand typically contained only free water and was rated as hazy and cloudy. Effluent samples of the coalescer were bright and clear with water concentrations ranging from 4 ppm to 6 ppm. The effluent samples' haze clear-up temperatures measured by Refinery B, ranged from 68°F to 81°F. Typical haze clear-up temperatures of salt-dried diesel between 90°F to 100°F, well above the specification of the Colonial Haze test of 70°F.

**Table 4. Summary of test coalescer test results at Refinery B**

Fluid: #2 Diesel  
Viscosity: 4.0 cSt at 100°F  
Fluid temp.: 98°F

Flow, gpm	Stack pressure drop, psid	Coalescer inlet free water, ppmv	Coalescer outlet free water, ppmv	Haze clear-up temp., °F	
				Coalescer	Drier
0.5	1	150	*	*	95
1	2	150	4	81**	95
1.5	3	150	6	68**	95
2	4	150	6	68**	95

\* Not measured for this run.

\*\* Visual test was "bright and clear."

Field test results indicate that the water removal performance of the newer liquid/liquid coalescer compared to a salt drier and may be used in place of, or in conjunction with, a salt drier to get effluent water removal from refinery fuels, as well as reduce maintenance and operating costs.

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## References

- <sup>1</sup> Hu, S., and R. C. Kinter, *A.I.Ch.E. Journal*, 1955, p. 42.
- <sup>2</sup> Bevis, A., "The Treatment of Oily Water by Coalescing", *Filtration and Separation*, July, 295-300.
- <sup>3</sup> Field tests of refinery gasoline and diesel streams conducted by Pall Corp.
- <sup>4</sup> 1980 NPRA Q&A Refining Technology, Question 7, p. 14.
- <sup>5</sup> 1992 NPRA Q&A Refining Technology, Question 11, pp. 14-15.
- <sup>6</sup> 1992 NPRA Q&A Refining Technology, Question 7, p. 12.
- <sup>7</sup> Specifications and Qualification Procedures, Aviation Jet Fuel Filter/Separator, *API Bull* Second Edition, June 1980.

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## The authors

**Robert L. Brown, Jr.**, is a marketing manager for Pall Process Filtration Co., a division of Pall Corp. previously a senior engineer assigned to various process units at Exxon Co. USA's Baytown, Texas. He was a project coordinator at UOP in Des Plaines, Ill. Mr. Brown holds a BS degree in chemical engineering and a BA degree in chemistry from the University of Kansas and an MBA degree from the Kellogg Graduate School of Management, Northwestern University. He is a member of A.I.Ch.E.

**Thomas H. Wines** is a senior test engineer with the Scientific and Laboratory Services Department. His experience includes five years of troubleshooting refinery and gas plant filtration applications. He is a specialist in the fields of liquid/gas and liquid/liquid coalescing. He holds a BS degree in chemical engineering from Fordham University and an MS degree in chemical engineering from Columbia University. Mr. Wines is completing studies for a PhD degree in chemical engineering at Columbia University and is a member of the Society of Petroleum Engineers.

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